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Response of pigeonpea (*Cajanus cajan*) + groundnut (*Arachis hypogaea*) intercropping system to planting pattern and phosphorus management

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ABSTRACT

A field experiment was conducted at New Delhi during the rainy season of 2000 and 2001, to study the effect of planting pattern and P-fertilizer management in pigeonpea [*Cajanus cajan* (L.) Millsp.] + groundnut (*Arachis hypogaea* L.) intercropping system. Planting patterns failed to affect the growth and yield attributes, protein content and yield of pigeonpea. Groundnut in all the intercropping treatments being at par recorded significantly lower yield attributes (except 1,000-seed weight) and yield compared with sole groundnut. Pigeonpea + groundnut intercropping in various planting patterns being at par recorded significantly higher pigeonpea-equivalent yield (PEY) and P uptake than sole pigeonpea. Both pigeonpea and groundnut in sole and intercropping systems responded favourably up to 40 kg P_2O_5/ha only for growth and yield attributes (except 1,000-seed weight and harvest index), protein content, yield, PEY and P uptake over no phosphorus.

Key words : Intercropping, Pigeonpea, Groundnut, Pigeonpea-equivalent yield

Pigeonpea is a major pulse crop in India and is grown either as a sole crop or in combination with various other crops, mainly as an intercrop. The current shortage of both pulses and vegetable oils in India has stimulated thought on developing new systems of pigeonpea and groundnut intercropping. The advent of short-duration varieties of pigeonpea, which are relatively photoperiod insensitive, opened up the new avenues in the direction of intercropping. There is a need to bring in sustainability both in productivity and in the economy of the Indian farmers. The approach may involve growing of a long-duration crop like pigeonpea with groundnut, so that the loss sustained if any in groundnut may be compensated with long-duration crop. Pigeonpea, yet another very important crop is being grown extensively in the region with wider row distances of 60 to 90 cm. Intercrops between the wider row distances of pigeonpea could successfully be grown as the growth of pigeonpea in the early stages of its development is slow. Therefore to make intercropping effective and remunerative, it is necessary to mitigate competition by modifying the planting pattern of the dominant crop.

Intercrop performance depends on many factors and constant reappraisals of the system are necessary due to the introduction of new cultivars and the possibility of extending the system into new areas. Therefore, an attempt was made to determine the influence of pigeonpea row arrangement and P fertilizer on the plant development and yield of pigeonpea and groundnut in intercropping system.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 2000 and 2002 at the I.A.R.I., New Delhi, under irrigated conditions. The soil was sandy loam, with pH 8.1 and analysed low in organic carbon (0.36%), total nitrogen (0.0185%) and available phosphorus (8.30 kg/ha). The treatments consisting of 5 planting patterns (sole pigeonpea, sole groundnut, pigeonpea 45//75 cm + 2 rows of groundnut, pigeonpea 30//90 cm + 2 rows of groundnut and pigeonpea 60 cm + 2 rows of groundnut) as main plots and 4 levels of phosphorus [no fertilizer, 40 kg P_2O_5/ha, 40 kg P_2O_5/ha + phosphate-solubilizing bacteria (PSB) and 80 kg P_2O_5/ha] as subplots were replicated thrice in split-plot design. Rainfall of about 500 mm was received, distributed uniformly during both the cropping seasons of 2000 and 2001. The seed rate was 15 kg/ha for pigeonpea and 100 kg/ha for groundnut. Seed rate was regulated according to the proportion of area under each crop component in intercropping situations. Both the crops were sown simultaneously in mid-June in both the years. A uniform basal dose of 25 kg N/ha as urea to all the plots and the entire dose of phosphorus as per treatments was applied at sowing. Seeds were inoculated with specific and efficient strain of PSB, viz. microphos (*Pheudomonas striata*) before sowing.

RESULTS AND DISCUSSION

Pigeonpea

Growth: Planting pattern failed to affect the plant height of pigeonpea (Table 1). This might be due to the absence of competition for growth resources between component crops, which have differential growth rhythm. Giri (1990) also observed similar behaviour in pigeonpea + groundnut intercropping. The plant height recorded marked increase up to 40 kg P_2O_5/ha only (Table 1). The improvement in growth of pigeonpea with the application of P fertilizer could be ascribed to its pivotal role in several physiological and biochemical processes, viz. root development, photosynthesis, energy transfer reactions and symbiotic biological nitrogen fixation-process.

Yield attributes: Planting patterns had no significant effect on pods/plant, seeds/pod, 1,000-seed weight and harvest index (%) of pigeonpea (Table 1). This could be attributed to identical conditions for crop growth under sole and intercropping systems due to their differential growth habit, viz. canopy height, growth duration etc. The yield attributes (pods/plant, seeds/pod and 1,000-seed weight) and harvest index (%) recorded marked increase up to 40 kg P_2O_5/ha only (Table 1). The improvement in yield components might have resulted from favourable influence of phosphorus nutrition on the growth attributes, viz. plant height, leaf-area index (LAI), branching and dry-matter accumulation, as a consequence of greater nutrient uptake, efficient partitioning of metabolites and adequate translocation and accumulation of photosynthates. Sharma and Rajput (1996) also made similar observation.

Yield : Planting pattern had no effect on grain yield (Table 3). As stated earlier, the growth and development of pigeonpea in sole and intercropping was similar, which was finally reflected in yield attributes and yield of pigeonpea. Giri (1990) and Gupta and Rai (1999) also noted similar behaviour in pigeonpea + groundnut intercropping system. The grain yield markedly increased up to 40 kg P_2O_5/ha only (Table 1) as a result of improved growth, translocation of more photosynthates towards sink and consequent increase in yield-attributing characters. These results are in conformity with the findings of Srivastava and Srivastava (1993).

Protein content: Intercropping of pigeonpea with groundnut did not affect the protein content in seed of pigeonpea compared to sole pigeonpea (Table 3). This might be attributed to the similar N content in seed in intercropped and sole pigeonpea. The protein content in seed significantly increased up to 40 kg P_2O_5/ha only (Table 3). Phosphorus being responsible for synthesis of RNA and an ingredient of phospho-proteins plays a central role in synthesis of proteins. Jat and Ahlawat (2001) also reported improvement in protein content in grain due to phosphorus.

Groundnut

Growth: The intercropped groundnut recorded significantly taller plants over sole groundnut (Table 2). This could be attributed to lanky growth of groundnut due to shading effect of pigeonpea at the later stages of crop growth. Thakur and Sharma (1988) also observed similar results. The plant height significantly increased up to 40 kg P_2O_5/ha only (Table 2). This could be attributed to greater availability of P, since it is known to influence the rate of photosynthesis favourably owing to its direct involvement in energy transfer reaction and biological nitrogen fixation.

Yield attributes: Planting pattern had marked influence on pods/plant. All the intercropping treatments being at

Table 1. Growth and yield attributes of pigeonpea as influenced by intercropping and P-fertilizer

Treatment	Plant height (cm)		Pods/ plant		Grains/ pod		1,000-grain weight (g)		Harvest index (%)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Planting pattern										
Sole pigeonpea	228.5	231.7	144.3	145.9	3.5	3.6	65.9	66.4	16.8	16.8
PP 45//75 cm + 2 rows of GN	231.6	233.7	148.7	151.1	3.6	3.6	66.1	66.5	16.5	16.2
PP 30//90 cm + 2 rows of GN	232.5	235.1	150.1	152.8	3.6	3.6	66.1	66.5	16.3	16.6
PP 60 cm + 2 rows of GN	232.9	235.7	151.9	154.2	3.6	3.7	66.1	66.6	16.5	16.4
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P-fertilizer										
None	221.8	225.2	133.8	136.1	3.5	3.5	65.4	66.0	16.5	16.5
40 kg P_2O_5/ha	233.7	235.7	150.2	152.8	3.6	3.6	66.1	66.5	16.5	16.5
40 kg P_2O_5/ha + PSB	234.5	237.1	154.8	156.2	3.6	3.6	66.3	66.7	16.5	16.5
80 kg P_2O_5/ha	235.5	238.2	156.2	158.9	3.6	3.7	66.4	66.8	16.5	16.5
CD (P=0.05)	9.0	9.1	12.9	13.5	0.1	0.1	NS	NS	NS	NS

PP, Pigeonpea; GN, groundnut; PSB, phosphate-solubilizing bacteria

par produced significantly less pods/plant, kernels/pod and harvest index than sole groundnut (Table 2). This is because of poor growth and development of groundnut plants due to inter- and intra-row competition for growth resources and reduced translocation of photosynthates to various plant parts when it was intercropped with pigeonpea. Sole groundnut registered higher shelling percentage than intercropped groundnut, as the number of immature and unfilled pods was higher in intercropping resulting in lower pod weight and shelling percentage. The yield attributes (pods/plant, kernels/pod, shelling percentage and harvest index) showed improvement up to 40 kg P_2O_5/ha only (Table 2). The improvement in yield attributes by P application could be attributed to better development of growth attributes on account of greater nutrient uptake and their translocation favourably affecting the rate of photosynthesis and accumulation of photosynthates.

Yield: The intercropped groundnut in 3 planting patterns being at par resulted significantly lower pod and haulm yield than sole groundnut (Table 1). Better performance of sole crop of groundnut could be attributed to more pods/plant, kernels/pod and harvest index. Assimilation and distribution of photosynthates were mainly responsible for higher yields in sole groundnut. Besides, sole groundnut had less immature and unfilled pods/plant than intercropped groundnut. Moreover, reduced plant population (42% in 30//90 and 45//75 cm and 83% in 60

Table 2. Growth and yield attributes of groundnut as influenced by intercropping and P-fertilizer

Treatment	Plant height (cm)		Pods/ plant		Kernels/ pod		1,000-kernel weight (g)		Shelling percentage		Harvest index (%)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Planting pattern												
Sole groundnut	31.2	31.6	14.5	17.1	1.6	1.8	270.1	280.3	63.1	65.3	23.3	24.4
PP 45//75 cm + 2 rows of GN	36.0	36.4	9.0	11.3	1.5	1.6	255.3	261.2	46.6	48.7	12.6	13.2
PP 30//90 cm + 2 rows of GN	35.4	35.5	9.4	11.5	1.5	1.6	258.4	265.5	52.2	53.2	13.0	12.9
PP 60 cm + 2 rows of GN	39.4	39.9	8.1	9.4	1.4	1.6	250.2	256.0	51.8	51.0	12.4	13.4
CD (P=0.05)	3.9	3.9	2.1	2.3	0.1	0.2	NS	NS	8.3	8.7	1.4	1.5
P-fertilizer												
None	31.4	31.6	6.4	6.6	1.4	1.5	254.1	259.4	46.2	43.1	18.5	19.2
40 kg P_2O_5/ha	35.3	35.7	10.7	13.3	1.5	1.6	257.6	265.0	53.2	55.7	18.3	18.8
40 kg P_2O_5/ha + PSB	37.3	37.6	11.8	14.6	1.5	1.7	261.0	268.3	57.2	59.3	18.3	18.9
80 kg P_2O_5/ha	38.1	38.6	12.3	14.8	1.6	1.7	261.3	270.2	57.1	60.2	18.5	18.8
CD (P=0.05)	3.0	3.2	1.8	1.9	0.1	0.1	NS	NS	6.7	6.8	NS	NS

PP, Pigeonpea; GN, groundnut; PSB, Phosphate-solubilizing bacteria

Table 3. Productivity and protein content in grain or kernel of pigeonpea and groundnut as influenced by intercropping and P-fertilizer

Treatment	Yield (q/ha)				Pigeonpea-equivalent yield (q/ha)		Protein(%)				P uptake (kg/ha) by system	
	Pigeonpea		Groundnut				Pigeonpea		Groundnut			
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Planting pattern												
Sole pigeonpea	18.5	20.0			18.5	20.0	19.4	19.5			16.78	18.45
Sole groundnut			23.5	25.6	23.9	26.0			25.1	25.4	21.04	22.98
PP 45//75 cm + 2 rows of GN	19.2	20.6	3.5	3.9	22.8	24.6	19.6	19.8	25.9	25.9	22.78	25.45
PP 30//90 cm + 2 rows of GN	20.2	21.8	4.1	4.5	24.3	26.4	19.7	20.1	25.9	25.9	24.35	27.03
PP 60 cm + 2 rows of GN	20.4	22.0	4.3	4.8	25.0	26.9	19.7	20.1	25.8	25.8	24.81	27.42
CD (P=0.05)	NS	NS	1.7	1.6	2.7	2.9	NS	NS	NS	NS	2.25	2.32
P-fertilizer												
None	15.4	16.7	6.5	7.3	17.7	19.2	18.9	19.1	24.6	24.8	15.84	17.62
40 kg P_2O_5/ha	20.6	22.3	9.2	10.2	24.0	26.1	19.7	19.9	25.9	26.0	23.19	25.58
40 kg P_2O_5/ha+ PSB	21.0	22.5	9.5	10.6	24.5	26.6	19.8	20.3	26.1	26.1	23.96	26.56
80 kg P_2O_5/ha	21.3	22.9	10.2	10.7	25.3	27.1	19.9	20.3	26.1	26.1	24.82	27.30
CD (P=0.05)	2.6	1.4	1.1	1.2	2.0	1.5	0.5	0.7	1.0	1.0	1.75	1.89

PP, Pigeonpea; GN, groundnut; PSB, phosphate-solubilizing bacteria

cm planting pattern of pigeonpea) coupled with poor plant growth and development of groundnut in intercropping were largely responsible for poor yields. Similar observations were also made by Shinde *et al.* (1990). The pod and haulm yields increased up to 40 kg P_2O_5/ha in both the years. Higher yields by P application could be attributed to better development of yield attributes.

Protein content: Planting pattern did not show effect on protein content in kernel (Table 3). This might be attributed to similar N content in kernel in sole and intercropped groundnut. Application of 40 kg P_2O_5 kg/ha with and without PSB and 80 kg P_2O_5/ha being at par recorded significantly higher protein content than no phosphorus (Table 3). Phosphorus is responsible for the synthesis of RNA and phosphorus itself is an ingredient of phosphoproteins. This led to increase in protein content with the application of phosphorus.

Pigeonpea-equivalent yield (PEY)

Pigeonpea+groundnut intercropping in various planting patterns (pigeonpea 45//75 cm + 2 rows of groundnut, pigeonpea 30//90 cm + 2 rows of groundnut and pigeonpea 60 cm + 2 rows of groundnut) and sole groundnut were at par but recorded significantly higher PEY than sole pigeonpea (Table 3). This was due to similar yield performance of pigeonpea in sole and intercropping systems and an extra yield of groundnut as bonus in intercropping system. Since the yield and the market rate of groundnut had an edge over the rate of pigeonpea, sole groundnut ranked next to all pigeonpea + groundnut intercropping systems. Sharma and Rajput (1996) also observed similar results. The PEY showed marked response up to 40 kg P_2O_5/ha only. As both the component crops responded favourably up to 40 kg P_2O_5/ha only, response in terms of PEY was also confined to this level of P.

P uptake by cropping system

All the intercropping treatments being at par recorded higher P uptake than both the sole crops, except pigeonpea 45//75 cm + 2 rows of groundnut which had similar P uptake to that of sole groundnut. The identical yield and P content of pigeonpea in both sole and intercropping and additional P removal by groundnut crop consequently led to higher P uptake in intercropping systems. Similar behaviour in this cropping system was also observed by Srivastava and Srivastava (1997).

Phosphorus application had a marked effect on P uptake. Application of 40 kg P_2O_5/ha with and without PSB being at par had higher P uptake over no P fertilizer. The increased biomass (grain and stalk or haulm) and its higher P content in both the crops in sole and intercropping by P application resulted in higher P uptake by the system.

REFERENCES

Giri, G. 1990. Studies on pigeonpea + groundnut intercropping under rainfed condition. *Indian Journal of Agronomy* **35** (4) : 446–449.

Gupta, A.K. and Rai, R.K. 1999. Phosphorus use efficiency of intercropping versus sole cropping. *Journal of Eco-Physiology* **2**(2-3) : 59–62.

Jat, H.S. and Ahlawat, I.P.S. 2001. Effect of land configuration, post-monsoon irrigation and fertilizer application on pigeonpea (*Cajanus cajan*). *Agronomy Digest* **1** : 52–55.

Sharma, R.K. and Rajput, O.P., 1996. Crop geometry and nutrient management in pigeonpea (*Cajanus cajan*) + groundnut (*Arachis hypogaea*) intercropping system. *Indian Journal of Agronomy* **41**(2) : 329–331.

Shinde, S.H., Dandavade, V.G., Magdum, G.D., Pol, P.S. and Umrani, N.K. 1990. Studies on planting pattern of pigeonpea and groundnut intercropping systems during summer. *Indian Journal of Agronomy* **35**(1-2) : 67–72.

Srivastava, G.P. and Srivastava, V.C. 1993. Fertilizer management in pigeonpea based intercropping system. 1. Crop productivity and competitive relationship. *Journal of Research, Birsa Agricultural University* **5**(2) : 157–161.

Srivastava, G.P. and Srivastava, V.C. 1997. Fertilizer management in pigeonpea based intercropping system. III. Effect on nutrient removal. *Journal of Research Birsa Agricultural University* **9**(1) : 43–47.

Thakur, H.C. and Sharma, N.N. 1986. Intercropping of maize with short-duration pigeonpea and groundnut. *Indian Journal of Agricultural Sciences* **58** (4) : 259–262.